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Wood Preservation

**PRESERVATIVE TREATMENT OF GREEN BAMBOOS  
UNDER LOW PNEUMATIC PRESSURES**

BY

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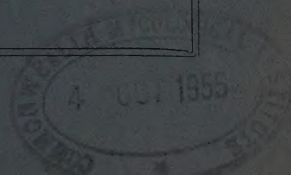


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## SUMMARY

Timber is generally treated with preservatives after drying it to a moisture content of 10 to 12 per cent. It is at times treated in green condition also. This paper gives brief descriptions of the methods employed hitherto for the treatment of living trees and freshly felled timber, and discusses their applicability to the treatment of bamboos which are one of the most important cheap structural materials in the tropics, particularly in India, and other Asian countries. Bamboos compare favourably with such reputed structural timbers as sal and teak, in strength properties. But bamboos have a low natural durability against attacks by fungi and insects - 1 to 3 years. They are also very difficult to treat by normal wood preservation methods in dry condition since their outer and ( to some extent ) inner membranes are impermeable to liquids. The treatment of bamboos is, therefore, best carried out in green condition by the Boucherie process, which takes about 5-6 days for completion of the treatment.

In recent experiments carried out and reported in this paper, it is possible to reduce this time to 3-4 hours by application of pneumatic pressures over the preservative, which is of the water soluble type, contained in a suitable reservoir. The reservoir is attached to the bamboo by a thick walled rubber tube. Such treated bamboos can be expected to last over 15-20 years in the open, and 25-30 years under cover. An advantage of this type of treatment, particularly with bamboos, compared to treatment of dry timber by pressure processes is that the preservative does not spread on the surface, and is also not easily leached out by water when used in round form.

The paper also gives details on the distribution and availability of bamboos in India ; information on their strength, seasoning characteristics and natural durability ; and an account of the diverse uses to which bamboos are put.

The paper gives illustrations of the treatment of bamboos by the above mentioned method and also illustrations of the various uses to which bamboos are put. In addition, details on the requirements of treated timbers, bamboos and thatch grass for building different sizes of houses using reinforced bamboo walls and thatch roofs are given. Tables showing details on the preservatives to be used for the treatment of bamboo for diverse purposes, their availability, approximate cost and recommended absorptions for estimated service life are also given.



## PRESERVATIVE TREATMENT OF GREEN BAMBOOS UNDER LOW PNEUMATIC PRESSURES

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### INTRODUCTION

The preservative treatment of wood for protection against fungi and insects, as mentioned earlier<sup>1</sup>, has been practised from time immemorial. But wood, in general, has to be dried to a moisture content of 10 to 12% before impregnation with preservatives, particularly of the oil type.

### METHODS OF TREATMENT OF LIVING TREES AND GREEN TIMBER

The discovery in 1709<sup>2</sup> of the movement of sap in living trees opened a new field of attack for the introduction of chemicals soluble in water in the sap stream, for diverse purposes<sup>3</sup>, viz. : (a) preserving non-durable woods, (b) staining wood for cabinet work, (c) artificial feeding of trees with nutritional elements, (d) pathological protection of forests and ornamental trees from insects and other diseases, (e) killing undesirable forest trees (silvicultural practice), (f) fire-protection of trees and (g) treatment with water soluble, water dispersible, alcohol or acetone soluble synthetic resins and other chemicals like zinc chloride, urea, urea-formaldehyde, phenol-formaldehyde, etc., which can impart better strength and/or dimensional stability to inferior woods. In 1873, Boucherie gave a new impetus to the problem by extending the treatment to freshly felled trees by the 'capping' method. Short descriptions<sup>3b</sup> of the methods employed hitherto for the treatment of green trees or poles are given below.

*Dry Packing Method*—In this process, about 10 inches wide horizontal strip of bark and phloem is removed, preferably at the base of a tree, and the chemical either as dry powder or in a paste form is held using a water-proof wrapping material, such as an inner tube of a motor tyre. The preservative dissolves in the sap and is carried with it upwards along the stream.

*Banding Method*—While in the older method a horizontal cut is made in the tree, in the new method a spiral kerf or groove is made approximately 1/2 inch deep into the wood, near the centre of a 10 inches wide, barked, spiral zone close to the base of a tree, the ends of the groove overlapping an inch or so. A 1/4 inch hole is next bored through the wood from one end of the groove, opening on the surface of the bole, 2 or 3 inches away and one end of a section of 1/4 inch rubber tubing is run all the way through it. A piece of stout rubber banding is stapled tightly to the tree over the spiral groove so that when in place, the band is stretched to about 1/2 again its original length. A container of preservative is fastened to the tree above the band, and the loose end of the rubber tube is connected to it. The solution is thus syphoned or run by gravity into the groove which mixes up with the sap and is carried with it into the tree.

*Bore-hole Method*—The method consists of boring a suitable number of holes at the base of a tree about an inch in diameter and 4-6 inches long, tangentially downwards through the sapwood, and feeding these holes with preservative chemical solutions through a rubber tube attached to convenient containers held 4-5 feet up on the tree.

*Collar Method*—In this method, the bark of a tree is removed about 10 inches wide at the base, and a kerf or a groove about 1/2 inch deep and about 1 inch wide is made at the centre

of the debarked portion, leaving an inch gap of clear wood between the ends of the groove. A suitable waterproof material is banded over this, over-lapping at the portion where the groove has been left out, and nailed on to the tree. Preservative solution is then poured through a small opening by stretching out the collar at the top. The preservative is absorbed, by the tree, as it dissolves in the moving sap.

*Stepping and Capping Method*—These two methods differ from the methods described above in that the tree is severed completely from its base. In the stepping method, the tree is placed in a suitable tank containing the preservative (with its butt end dipping in the solution) and is held upright supported against a neighbouring tree. The preservative is sucked up during the transpiration of the leaves. In the capping method, the crown is cut off and about 6 inches of bark is removed at the butt end. An old inner rubber tube of a motor tyre is tightly fixed at the debarked place and the tree is held either horizontally to the ground or made to lean on the ground with its butt end resting on a neighbouring tree about 8-10 feet above the ground. The free end of the tube which is held upright is then filled with the preservative which flows down its length under hydrostatic pressure. Where necessary the tube may be attached to a container for holding greater quantities of the preservative. In this method, the branches of the tree can be removed and the cut portions sealed off with asphalt roofing compound to prevent loss of preservative by leaking.

Several minor modifications of the above processes are also reported in the literature, for example Ludwig and Gewecke (German Patent 1943) allowed the preservative liquid to flow through from both ends to the centre of a pole, and some commercial concerns<sup>3c</sup> in the U.S.A. are reported to partially season large poles and use artificial pressures to inject the preservative.

While most of the methods mentioned above are quite ingenious and are applicable for the treatment of a limited number of trees for special purposes, they have never gained any popularity in actual wood preservation practices on a commercial scale, except perhaps the Boucherie process which generally extends over a period of a week or two depending upon the size and species of timber experimented upon. Quite a large number of poles and fence posts in green condition are said to have been successfully treated by the Boucherie process in France, the U.S.A., etc. Gäumann<sup>5</sup> reports that Swiss postal authorities successfully treated telegraph poles by the Boucherie process using copper sulphate and obtained an average life of 22.5 years. In some areas the poles, however, gave an average life of only 14.5 years, the rejections being mainly due to attack by *Polyporus vaporarius*. In India, too, the M.S.M. Railway (now the Southern Railway) is said to have treated in 1865<sup>6</sup> green timber by this process at Palghat using copper sulphate and then converted them into sleepers for use on their lines. Very little information, however, seems to be available in the already extensive literature on the subject, on the application of these methods to the treatment of green bamboos, probably because bamboos are not available in those countries in which these methods were extensively tried.

#### DESCRIPTION AND OCCURRENCE OF BAMBOOS IN THE WORLD

Bamboos<sup>7a</sup> are tall, arborescent grasses belonging to the Bambuseae, a tribe of Gramineae. They grow either as shrubs or trees, very rarely herbs, culms erect or sometimes climbing, often tall, usually woody. They are primarily tropical in origin, thriving best in monsoon forests where they attain their maximum development and dwindle into under shrubs in temperate regions, and take the form of 'grasses' at high altitudes - 12,000 feet, almost to the snow line, in the South American Andes.

The bamboo belongs to four sub tribes : Arundinarieae, Eubambuseae, Dendrocalameae, and Melocanneae. There are about thirty genera and 550 species. Asia and South America account for 320 and 179 species respectively. About 136 species occur in India, 39 in Burma, 29 in Malaya and the Andamans, 9 in Japan, 30 in Philippines, 8 in New Guinea and a few in South America and Queensland. The more important genera of bamboos are *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Dendrocalamus*, *Gigantochloa*, *Melocanna* and *Ochlandra*. Most of these are indigenous to India, Burma, South China and Malaya, and a few to South America. There is only one species of uncultivated bamboo, viz., *Arundinaria macrosperma* in the whole of North America and North Mexico. In Europe, there is not one native species but some have been introduced into Europe and Australia. Some species of bamboos are also grown as ornamental trees in Japan.

#### DISTRIBUTION OF BAMBOOS IN INDIA

"In<sup>7b</sup> India, the bamboos form rich belts of vegetation in the well-drained parts of the monsoon region at the foot of the Himalayas, and rise up to about 12,000 feet, almost to the snow line. Their distribution is quite dense in Burma, Assam and Bengal, the north-eastern Himalayas, the Western Ghats, Ceylon and Andamans. The principal genera of bamboos met with in India are – *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Dendrocalamus*, *Gigantochloa*, *Melocanna* and *Ochlandra*. To mention the distribution of some of the important species – *Bambusa arundinacea* is found in Orissa, Assam, Eastern Bengal, South and Western India. *Bambusa vulgaris* in Assam and Burma; *Bambusa tulda* and *Bambusa balcooa* in Bengal; *Arundinaria aristata* in Eastern Himalayas and *A. wightiana* in the Nilgiris; *Bambusa polymorpha* in the upper mixed forests of Eastern Bengal and Assam; *Pseudostachyum polymorphum* in the valleys of Eastern Himalayas, Assam, Upper Burma and Sikkim. *Dendrocalamus strictus* in deciduous forests throughout India. The chief species in Northern Bengal and Assam is *Dendrocalamus hamiltonii*; in Eastern Bengal and Chittagong the most common kind is *Melocanna bambusoides*; *Cephalostachyum pergracile* is quite common in the moist parts of Bengal and Burma and also in Assam; *Oxytenanthera thwaitesii* is common in Western Ghats and Ceylon; *O. monostigma* common in Western Ghats from Konkan to Annamalai hills; *O. bourdillonii* is a common species in Travancore between 2,000–4,000 feet *Teinostachyum wightii* – found on the slopes of Western Ghat; *Ochlandra rheedii* is common in Malabar and Travancore and *O. travancorica* is spread in the mountains of South India".

Bamboos vary in size and yield per acre. The size depends upon the species, locality of growth, etc. For example<sup>8</sup> *Dendrocalamus giganteus* gives culms 120 feet long and 8–10 inches in diameter and *Arundinaria densifolia* gives culms hardly 3 feet long and 1/3 inch in diameter. Again while some bamboos like *Dendrocalamus strictus* are almost solid especially in the dry places, the rest are hollow, with the wall-size varying from 1/4–1/3 inch. Generally speaking it may be taken that the yield per acre is about 1 ton per year or 300 in number, the felling cycle being 3 seasons.

#### DIVERSE USES OF BAMBOOS

The bamboo is a very useful material, cf., plates 7–16. It is generally used for weaving baskets, house-hold articles like sieves, winnows and chicks. It is used as a base on which mud roofs are built, for construction of small bridges on canals and rivulets. Recent experiments in China, Japan and India reveal that it can be used for re-inforcing cement concrete in place of steel and also in re-inforcing mud walls. The first recorded use of bamboo rods in place of steel rods was in concrete piles, in China in 1919, by the Szechuan-Hankow Railway<sup>9</sup>. A 50 per cent saving in cost was effected from dollars 28 to 14 per mile. Bamboo reinforced concrete was next used in China for building roads. Reference is also made in engineering literature to a bamboo reinforced concrete hospital floor installed at Canton, China. Beautiful looking pale fencing and corrugated roofs can be built using split bamboos. In the villages it

is used extensively for house building, as rafters and purlins over which palmyra leaves and thatch grasses are used for roofing purposes. In the towns and cities, it is used very extensively for scaffolding work, house-hold aerial posts, and umbrella rods. It is the common Policeman's baton or scout's staff. In the field of agriculture it is used to give support against winds to sugarcane, plantain tree and betel vines, and as poles for "Aetham" or "Picottah", a device for taking out water from canals and wells for irrigation purposes. Mention should also be made of the recent development in the use of bamboo for making boards called "Ply-bamboo"<sup>10</sup>, using various types of glues and high pressures and temperatures to get compact and strong boards. This pioneer work of China is being followed up at the Forest Research Institute, Dehra Dun<sup>11</sup> with suitable modifications demanded by local conditions. Paper making is one of the chief commercial uses to which bamboo is put in this country. In the harbours, it is used, in bundles, as floating fenders and it is also generally used as rafts for the transport of logs in rivers and canals. The Defence department uses bamboos for tent posts and flagstuffs. It is said that in the olden days bamboos were used for distribution of drinking water in place of the modern metal pipes. The bamboo is otherwise also a useful material; its leaves are used as medicinal feed for the cattle after calving, the branches and leaves serve as normal fodder for elephants, the rhizomes and the seeds are pickled and cooked respectively for human consumption. The bamboo wax is used as a base for shoe polishes and carbon paper in place of carnaba wax, and recently a diesel fuel<sup>16</sup> oil is reported to have been manufactured from bamboo. Bamboo fibres are also carefully carbonized and used as filaments for carbon bulbs. These are generally used more for generation of heat than light.

#### STRENGTH OF BAMBOOS

The bamboo is structurally a strong material. It has long fibres with considerable tensile strength. Weight for weight it is even stronger than timbers like sal and teak as may be seen from the following<sup>12</sup> Table :

Species	Strength of Bamboos in lb./sq. in.			
	Moisture content	Modulus of rupture	Modulus of elasticity	Maximum crushing stress
<i>Dendrocalamus strictus</i> ..	{ 58	13,600	2,220	6,000
	{ 12	18,600	2,560	8,850
<i>Bambusa balcooa</i> .. ..	22	14,400	2,420	6,400
<i>Bambusa nutans</i> .. ..	12	9,400	1,580	..
<i>Bambusa tulda</i> .. ..	12	12,500	1,750	..
<i>Tectona grandis</i> ( teak ) ..	{ 52	11,400	1,670	5,850
	{ 12	1,51,000	1,880	8,800
<i>Shorea robusta</i> ( sal ) ..	{ 60	13,600	1,960	7,050
	{ 12	18,700	2,300	9,100

But as bamboos do not grow in sizes suitable for heavy constructional work like piles, beams, transmission poles, etc., they are not normally used for such purposes. The outer layers of bamboo are stronger than the inner layers. Bäumann<sup>11</sup> gives the following values :

		Outer layers	Inner layers
Bending strength lb./sq. in.	..	36,000	13,500
Tensile strength lb./sq. in.	..	44,000	21,000
		to	to
		47,000	23,000

Work on bamboo reinforcement was carried out in the U.S.A., Germany and Italy. In the U.S.A., tests showed that the bamboo reinforced concrete beams gave a strength of 20,000 lb./sq. in., in tension while steel reinforced beam 70,000 lb./sq. in.

As regards the variation of the strength of bamboo with its age, systematic investigations have been initiated in the Timber Mechanics Branch of this Institute and the present indications are that the strength rapidly increases in one to two seasons and reaches practically the maximum by about 3 seasons.

#### SEASONING OF BAMBOOS

Bamboos are best dried without serious damage by the air seasoning method, under cover, for a period of two to three months. Kiln seasoning under control conditions can be carried out successfully in about 2 to 3 weeks, but this process is considered uneconomical. The seasoning of bamboos is expected to be as satisfactory as of timbers of corresponding density. It is to be noted that the outer membrane of the bamboo and to some extent the inner membrane also are quite refractory and cause splitting of the bamboo under conditions leading to rapid drying.

#### NATURAL DURABILITY OF INDIAN BAMBOOS

Bamboos are easily susceptible to insect attack and moderately to fungal decay, *cf.*, plate 6, the deterioration due to "Lyctus" (powder post beetle) attack being the most severe and extensive. In the graveyard tests, *cf.*, plate No. 5, at the Forest Research Institute, *Dendrocalamus strictus*, *Bambusa tulda* and *Bambusa balcooa* gave an average life of 22, 32 and 41 months respectively; under cover they may be expected to last from 4 to 5 years depending upon severity of incidence of attack. In the sea waters, the bamboo is generally destroyed by marine organisms in less than 24 months. It is best stored under sweet water.

In recent work at Puerto Rico the incidence of attack, particularly due to *Dinoderus minutus*, is found to be directly proportional to the starch content. The relative susceptibility of 1 year old culms of eleven species varied from 44% in *B. vulgaris* var. *vittata* to 0.3% in *B. textiles*. On the whole, susceptibility increased from the base to the top of a culm. It was found that much damage could be avoided by harvesting culms of *B. vulgaris* in the third year or older, *B. tulda* and *B. tuldoidea* in the second year or older, and *Dendrocalamus strictus* and *Sinocalamus oldhami* during their 1st year of growth. Harvesting in August–December results in less infestation than harvesting in February–May. From the data obtained in the studies it does not appear that infestation can be avoided by harvesting according to the phases of the moon. Drying the felled culms at clump gave 90% control of infestation, best results being obtained in moist, hot weather, when the cut culms could be kept alive for a month or more, during which period most of the starch was depleted. Shed-curing for at least 8 weeks, thereafter, made culms even less susceptible. Infestation was reduced by 94% by placing the freshly cut culms in water and keeping them for 8 weeks, but this treatment stained the wood and made it light in weight and brittle.

#### STATISTICS ON THE AVAILABILITY OF BAMBOOS IN INDIA

The statistics<sup>14</sup> on the availability of bamboos in all the states of India are not complete. Table No. 6 gives the figures, so far obtained of bamboos taken out of forest areas and does not include figures of bamboos taken out of non-forest and agricultural areas. These show that about 9 lac tons of bamboos were taken out during 1948–49. It may be safely

taken that about 15 lac tons of bamboos may be available if systematic exploitation is carried out in all the states, the forest and non-forest areas being included for the purpose. Out of this, about 2 lac tons are being utilized by the paper industry alone. This figure is likely to increase by 50-75% in the next 5 years, thus leaving a meagre figure of 10-12 lac tons for the rest of the industries. A moderate house requires about a ton of bamboo for its construction. At the rate of building 25 lacs of houses a year, our housing problem can be solved in about 5-6 years. Therefore, the present outturn of bamboos should be very considerably increased by raising plantations in all forest areas and also on canal and river banks. Even then the full demand of bamboos for original structures cannot be met unless the present replacement cycle of 2-3 years for the old structures is increased. This can be done only by preserving bamboos on a mass scale and thus increasing their service life by 7-10 times their untreated life.

#### SERVICE DATA OF TREATED BAMBOOS (AIR-DRIED)

As mentioned earlier, very little published information is available on the preservative treatment of bamboos conducted in a systematic way. In the early (1925-42) experiments conducted in this Branch, dried bamboos were impregnated with both water soluble preservatives of the fixed type, and creosote-fuel-oil mixtures (50 : 50 by weight). Table No. 2 shows these results for round bamboos. It will be seen from the results that the absorptions have been anything but satisfactory even when pressure processes were employed; even with an absorption of 4-5 lb. per cu. ft. of creosote mixture most of the specimens were attacked by fungi and termites in less than 8 years service. This shows that the penetration of the preservative was quite poor. On the other hand dried bamboos split before pressure impregnation with ASCU, have been in the yard for over 14 years and they are still in a satisfactory condition. Unfortunately, data on the absorption of the preservative and corresponding treatment with creosote are not available.

#### SUMMARY OF PAST WORK CARRIED OUT ON THE TREATMENT OF GREEN BAMBOOS BY THE BOUCHERIE METHOD

During the war the preservative treatment of bamboos for the army became very urgent and since there was no time to be lost in drying the bamboos, treatment in green condition was undertaken. Results of these investigations are reported in two<sup>15a & b</sup> publications of this Institute. These indicate that for good protection against termites, fungi and borers, treatment by the Boucherie process (capping with old bicycle tubes) extending over 5-6 days is necessary. Similar experiments appear to have been carried out in Puerto Rico<sup>13</sup> using copper sulphate with satisfactory results. It is also reported that impregnation with synthetic resins made the bamboo immune to attack and imparted to it other desirable qualities.

#### TREATMENT OF GREEN BAMBOOS BY MODIFIED BOUCHERIE METHOD USING PNEUMATIC PRESSURE

It will be seen from the above that interesting as they are, the above experiments are frowned upon because they are commercially inadequate. An attempt was, therefore, made in recent months with the object of simplifying the method of treatment so as to make it commercially applicable for large scale treatment of bamboos in the forests and to cut down the period of treatment from a few days to a few hours. For this purpose the capping method was modified using 10-15 lb. pressure on the preservative contained in a closed vessel, and it would appear that this method is the first of its kind used for the treatment of green bamboos at any rate. These air pressures are intended to ensure better and quicker penetration, and

absorption of the preservative, and particularly to eliminate the unwieldy method of application of hydrostatic pressure involving the raising of the log or bamboo or the reservoir several feet high above the ground. Details of these experiments are given below.

The method of treatment of green bamboos is illustrated in plates 1, 2, 3 and 4. Plate 1 illustrates the case where a bamboo over 25 feet long or a log 15-20 feet long is fixed to the apparatus at 'C' either through a pressure rubber tube 'A' attached to the bamboo or a special clamp 'B' fixed to the log. In either case instead of the usual butt end, the thin end of the bamboo or log is attached to the apparatus since this has been found more convenient not only in making the connection easy and quick but also allowing the use of rubber tubes of small diameters, which are naturally cheap. For treating individual bamboos, as for example flagstuffs, aerial posts, badminton posts, etc., the apparatus in plates 2 and 3 are quite suitable. In plate 2, a container about 1-2 litres (old Dunlop or Slanzenger tennis ball tins) capacity is used as the reservoir. To the bottom end of the tin, a small metal tube about an inch in diameter is soldered. At the top, a metal plate is soldered to which are attached a bicycle valve and a pressure gauge which reads up to 30-50 lb. air pressures. A rubber tube is then fixed to the metal tube which serves to connect the top end of a bamboo to the reservoir. The connections of the rubber tube to the apparatus and the bamboo can be made firm by winding galvanized wire over the joints once or twice and twisting the ends with pliers or by means of any other suitable arrangement. After attaching the bamboo, the pressure gauge is taken out; the preservative is poured through the hole where the pressure gauge is fixed till the tin is filled to 3/4th its capacity. Filling is facilitated by removal of the valve, through which displaced air escapes. The valve and the pressure gauge are then replaced and air of 10-15 lb. is pumped in. It will be seen that in most cases within 2-3 minutes after pumping in the air, drops of sap start trickling down the butt end of the bamboo. After about 5 minutes the preservative starts flowing, mixed with the sap. The preservative actually enters the wall of the bamboo (through the fine pores in the wall of the bamboo) from the end which is fixed to the apparatus. It is through these fine pores the living bamboo takes in water from the soil through the root system. As the preservative flows down the bamboo it also fills in the septa (internodal partitions) at each node, and where there are branches even these get thoroughly treated. In fact even if the leaves are cut, one could see the preservative oozing out of the cut end of the leaves. Such is nature's complicated system of passage of water and food materials in a bamboo. As time passes, one could see the preservative dripping at the butt end along with sap juices. This liquid deepens in colour as more and more of the preservative comes out. The treatment is completed when the concentration of the effluent preservative, which can be judged by its colour in case of coloured liquids, is nearly the same as that contained in the reservoir. Thus it will be seen that in this case it is no longer necessary to incise the bamboo as was done in the earlier experiments reported in Bulletin No. 137 of 1947. In plate 3, a hose pipe of a suitable size is used; the open end being closed, after fixing the bamboo at the other end and pouring in the preservative, with a rubber stopper to which a bicycle or preferably a motor tube valve is fixed. In the latter case the pressure inside the system can be easily read by means of the usual pencil pressure gauge which motorists use. In plate 4, is shown how more than one bamboo, say four, may be treated simultaneously. Here a 4 gallon petrol tin is used. If instead of this a 45 gallon drum is used with suitable arrangements for fixing the bamboo, about 50-100 bamboos can be treated simultaneously. In all these cases, the preservative which has flown out at the butt end can be re-used after bringing up the concentration of the preservative to its original strength.

#### RESULTS AND DISCUSSION

The results of these experiments are given in Table Nos. 2 and 3. It will be seen from Table No. 2 that satisfactory absorption of zinc chloride is obtained in the case of the

two species of bamboo – *Bambusa polymorpha* and *Bambusa nutans* tried. As indicated in the earlier publication, an absorption of 0.5 lb. of zinc chloride per cubic foot of bamboo is considered sufficient for the protection of bamboo against decay and insect attack when used in the open, provided it is properly fixed. The minimum period of treatment and concentration of the preservative, can be varied depending upon the length and species of the bamboo used, after a few preliminary experiments. For use in the buildings, especially for reinforcing cement concrete or mud walls, an absorption of 0.3 lb. may be considered sufficient, that is, treatment should be continued for a minimum period of 2 hours and for prophylactic purposes 0.25–0.5 hours is sufficient. It will also be seen from experiment No. 15 that the absorption of the preservative in the septa is much more than that in the wall. This is because the septa contain comparatively very much bigger pores which get completely filled with the preservative. The function of sodium dichromate in this low concentration is to give colour to the solution and to protect the apparatus, especially the valves, from corrosion.

Table No. 3 gives elaborate data on the treatment of bamboos of the two species – *Bambusa polymorpha* and *Dendrocalamus strictus*. As complete a data as possible, on the age, the times taken for the first drop of sap and the preservative to flow out, the quantity of the preservative flowed out and that retained in the bamboo at the end of treating period, the sizes of the bamboo, and in some cases the quantity of the preservative by chemical analysis are given. Regarding the first few bamboos which were taken out from scattered clumps in the New Forest area and used for obtaining preliminary data the age is not known. But for the rest of the experiments only bamboos of known ages were used. Five preservatives have been tried in these experiments:—(a) Boliden salts, (b) ASCU, (c) Copper-chromeboric composition, (d) Chromated zinc chloride, (e) Fire-proof-cum-antiseptic composition. Except the last two, the others are patented compositions. All these preservatives other than (d) are of the fixed, water soluble type, i.e., they can be used for the treatment of timber, bamboo and grasses for outside use without fear of the preservative being leached out by rain or water in the soil, rivers, and canals. It will be seen from these experiments that in some bamboos the treatment has been very poor due to resistance to the flow of the preservative. The bamboo, like timber, is a naturally occurring bio-chemical product and its growth and structure are influenced by such varying factors like soil, environment, altitude and moisture. Thus it is not uncommon to note considerable differences in the physico-chemical properties of different species of trees or bamboos growing in the same area, same species growing in different places, and even at different points of the same tree or bamboo growing in any place. It is now proposed to investigate in detail, the cause of the obstruction to the flow of the preservative. With the increase in the age of the bamboo and decrease in the sap content, it is likely that structural deformations may be taking place causing both plugging in by chemicals and mechanical compression of the pores. To this may be added, another serious trouble which is caused by the entrance of air into these pores. Air bubbles, it may be mentioned, cause severe obstruction to the flow of liquids, particularly in fine capillaries, and very high pressures are required to eliminate them. As the bamboo normally attains sufficient strength for all practical purposes in 3 seasons, it is proposed to restrict the experiment to those age classes. This may be confirmed after further work in this direction and completion of the tests now under way in the Timber Mechanics Branch correlating age of bamboo of different species, with its strength.

It is now proposed to make a survey of the treatment of green bamboos available in all the states of India, in great detail, and also put up a semi-commercial treating plant at the Forest Research Institute, Dehra Dun, which can take up treatment of 50–100 bamboos at a time, and also develop simple field tests for the determination of the concentration of the dripping solution so as to enable non-technical men to fix the duration of the treatment. This will considerably help the introduction of this treatment on a mass scale in the forests on a cottage industry basis.



PLATE 3.



PLATE 4.

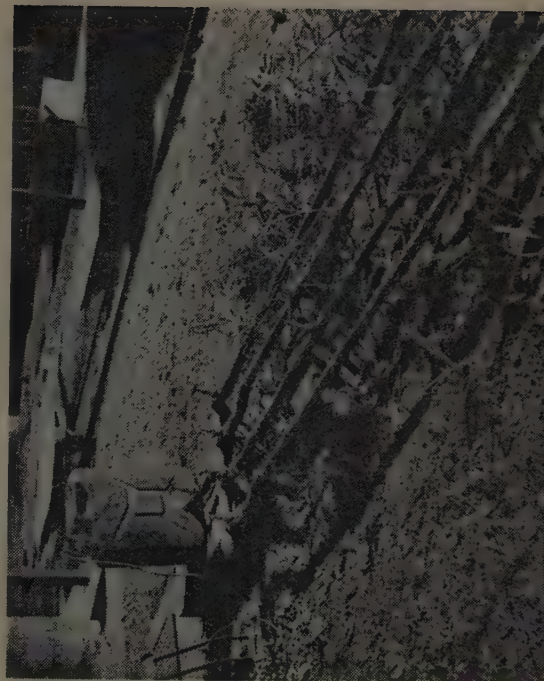




PLATE 5.—Graveyard for conducting durability tests on bamboos in the open at F.R.I.

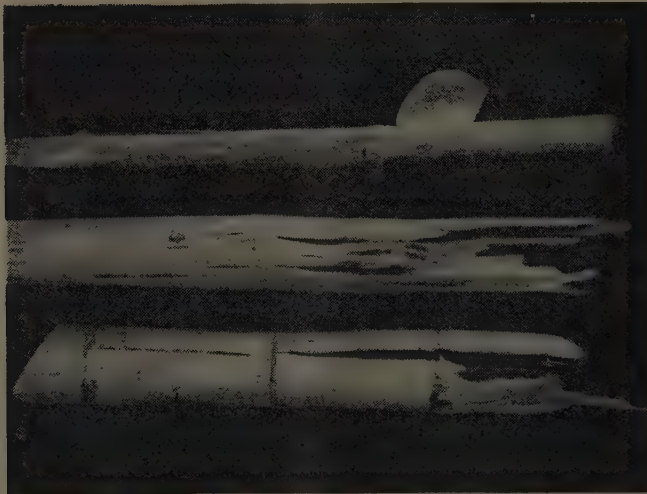


PLATE 6.—Untreated bamboo specimens attacked by fungi, termites and borers (top to bottom) in the tests at F.R.I.



PLATE 7.—Bamboo scaffolding work in Calcutta.

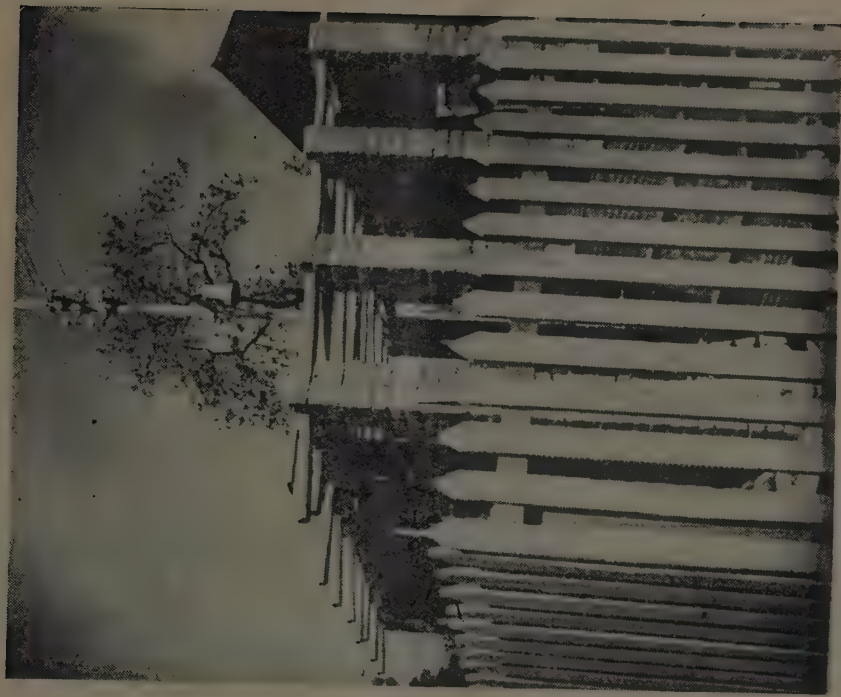


PLATE 8.—Fire-proofed bamboos as rafters at F.R.I.



PLATE 9(a) —Before erection.



PLATE 9(b).—After erection.

PLATES 9(a) and (b).—Treated timber, bamboos and thatch grass are used to construct the above shed for service tests at F.R.I.

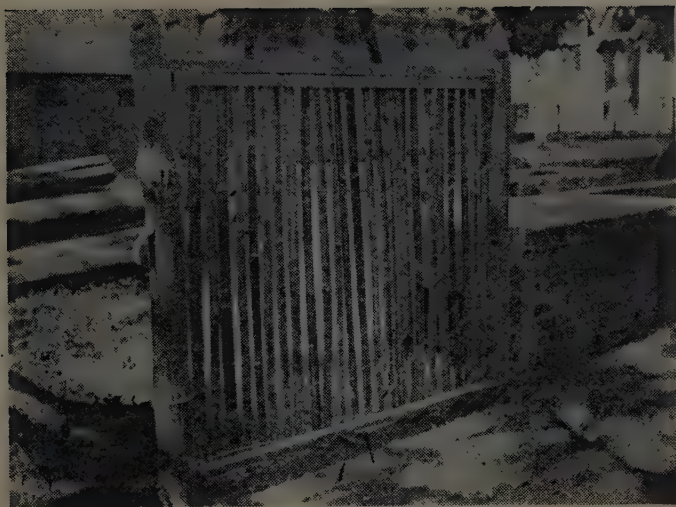


PLATE 10.—Treated split bamboo pale fencing at F.R.I.



PLATE 11.

- (1) Treated bamboo reinforced mud wall.
- (2) Treated bamboo mat used for door and window panels.



PLATE 12.  
ASCU treated split bamboo walls at  
Bhadrawati after 14 years service.



PLATE 13.  
Model of a house using corrugated  
bamboo roof.



PLATE 14.  
Corrugated treated bamboo roof and  
treated bamboo reinforced mud  
and cement walls undergoing  
service tests at F.R.I.



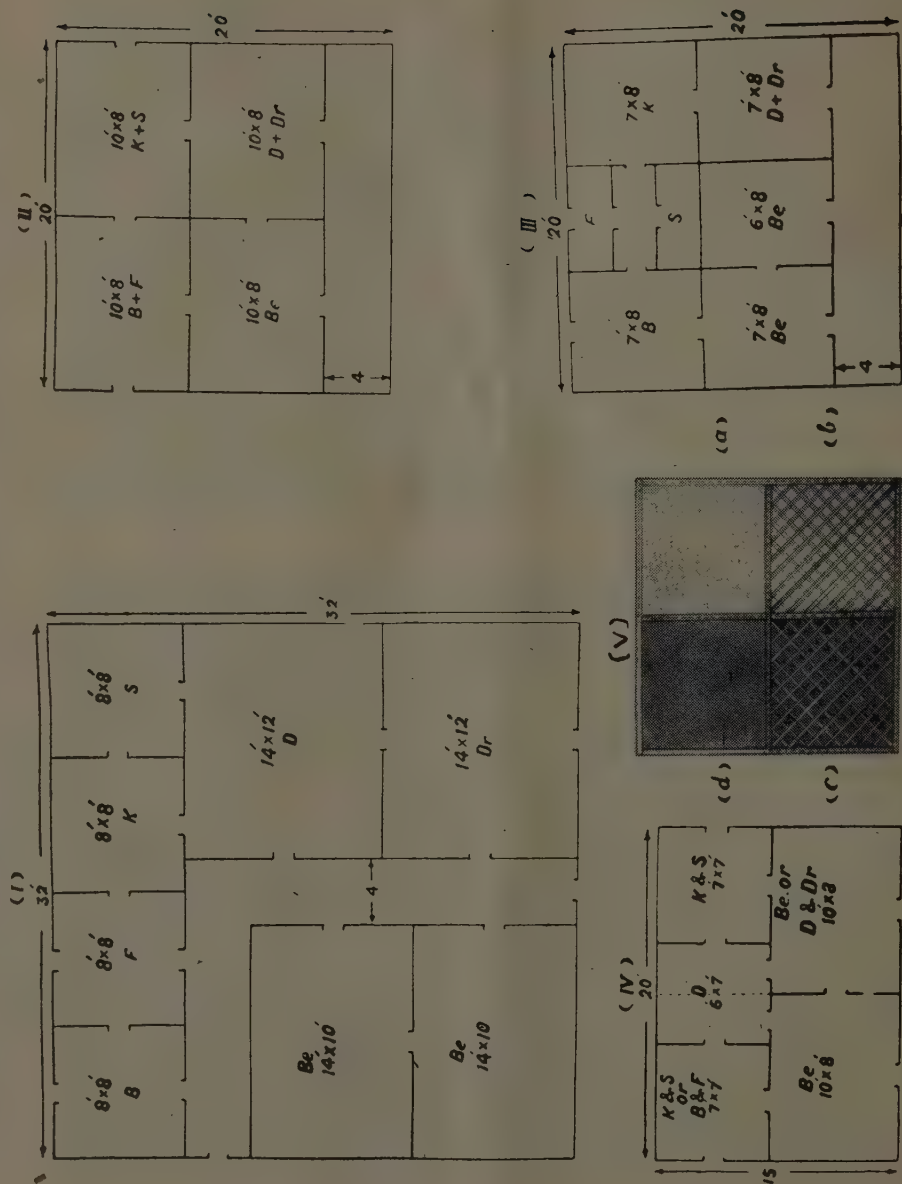
PLATE 15.—Model of a house using treated bamboo reinforced mud  
walls and roof of thatch grass treated against decay,  
insect attack and accidental fires.

PLATE 16.—Treated bamboo house undergoing service tests at Forest Research Institute, Dehra Dun.



(A) Galvanized corrugated iron roof, (B) Treated corrugated bamboo roof, (C) Treated half split bamboo strip wall, (D) Treated bamboo reinforced mud-wall plastered with stabilized earth mixed with treated saw-dust, (E) Treated bamboo reinforced cement concrete wall, (F) Same as 'D' but plastered with cement mortar, (G) Same as 'D' but plastered with lime mortar, (H) Treated bamboo reinforced mud-wall plastered with stabilized earth, (I) Treated bamboo reinforced mud-wall plastered with treated saw-dust, (J) Half split bamboo drainage, (K) Treated bamboo gutter pipe, (L) Treated bamboo fence including gate and turn-pike.

FIG. 1.—Diagram showing accommodation in four types of houses (I to IV) using bamboo (treated) reinforced mud or cement concrete walls and treated thatch grass roof. In No. V details of the construction of the wall are shown.



Legend:—Be - Bed room, B - Bath room, D - Dining room, F - Fuel room, K - Kitchen, S - Store room, a - Framework, b - Bamboo latticed work in 'a', c - Filling of 'b' with a mixture of mud and treated grass bits, d - Plastering of 'b' with cement concrete or 'c' with mud.

Note.—In addition to mud plastering, exposed walls (to rain) may be further covered with a thin layer of cement concrete or treated saw-dust mixed with stabilized mud.

TABLE NO. 1

## Results on the service life of treated and untreated bamboos ( air-dry )

Serial No.	Species	No. tested	Preservative used and its % conc.	Process of treatment	Absorption lb./cu. ft.	Date of laying	Date of inspection	Condition at the time of inspection		REMARKS
								Treated life in months	Untreated life in months	
1	..	6	Wolman salts 2.0	Full Cell :— Vac. 24" ; 30 mts. Pres. 175 ; 5 mts. Vac. 20" ; 10 mts.	..	19-11-29	3-10-31	Dwf : 20	Dwf : 17	
2	..	6	"	Cold soaking for 24 hrs.	..	"	"	Dwf : 20	Dwf : 17	
3	..	3	Cresote : fuel oil mixture ( 50 : 50 )	Pressure 175 for 30 mts.	0.047 per bamboo	8-7-35	13-11-45	Dw : 120	Dw : 17	3' long round.
4	..	3	"	"	"	"	"	Dw : 93	Dw : 17	3' long split.
5	..	3	"	Heating at 80°C. for 15 mts. and cooling 3 hrs.	0.021	"	"	Dw : 62	Dw : 17	3' long round.
6	..	3	"	"	0.026	"	"	Dw : 57	Dw : 17	3' long split.
7	<i>Dendrocalamus strictus</i>	11	"	Heating at 91°C. for 2 hrs. and cooling 18 hrs.	6.3	15-3-40	14-12-50	Dwf : 95	Dwf : 20	Bamboos 1.5' long.
8	"	11	"	Cold soaking for 48 hrs.	2.1	"	"	Dwf : 46	Dwf : 20	"
9	<i>Bambusa tulda</i>	3	Black varnish ( 100% )	Brush painting 2 coats	..	2-4-41	5-12-44	Dw : 28	Df : 32	
10	<i>Dendrocalamus strictus</i> ( green )	3	"	"	..	"	"	Df : 28	Df : 22	
11	"	3	Black varnish and fuel oil ( 50 : 50 )	"	..	"	"	Df : 29	Df : 22	
12	<i>Bambusa tulda</i>	3	"	"	..	"	"	Df : 37	Df : 32	

( contd. )

TABLE No. 1—( *concl'd.* )  
*Results on the service life of treated and untreated bamboos ( air-dry )*

Serial No.	Species	No. tested	Preservative used and its % conc.	Process of treatment	Absorption in lb./cu. ft.	Date of laying	Date of inspection	Condition at the time of inspection		REMARKS
								Treated life in months	Untreated life in months	
13	<i>Bambusa balcooa</i>	13	Cresote and fuel oil mixture ( 50 : 50 )	Heating at 95°C. for 6 hrs. and cooling 16 hrs.	4.4	9-10-42	6-2-53	Swf: 5 Mwf: 6 Bf: 1 Df: 1: 99	Dwf: 41	Poles 1½' long and about 3" diameter.
14	"	7	"	Dipping in oil at 95°C. for 2 hrs.	1.7	"	"	Dwf: 52	Dwf: 41	"
15	"	6	"	Full Cell :— Vac. 25' for 0.5 hr. Pres. 150 lb. for 1 hr. Vac. 25' for 0.3 hr.	4.9	"	"	Swf	Dwf: 41	"
16	"	6	"	Lowry :— Pres. 150 lb. for 1 hr. Vac. 25' for 0.3 hr.	4.3	"	"	Swf: 3 Mwf: 1 Bwf: 1 Df: 1:112	Dwf: 41	"
17	<i>Dendrocalamus strictus</i>	8	"	Full Cell :— Vac. 20' for 0.9 hr. Pres. 175 lb. for 1.5 hrs. Vac. 20' for 0.3 hr.	..	19-3-43	10-4-53	N: 1 Sw: 1 Sf: 1 Df: 5:105	..	Poles 8' long and 2" diameter.
18	"	8	"	Heating at 95°C. for 4 hrs. and cooling 18 hrs.	..	"	"	Sf: 1 Df: 7: 92	..	
19	<i>Bambusa arundinacea</i>	8	"	Full Cell :— Vac. 20' for 0.9 hr. Pres. 175 lb. for 1.5 hrs. Vac. 20' for 0.3 hr.	..	"	13-3-53	Dwf: 88	..	Poles 8' long and 2" diameter.
20	"	8	"	Heating at 95°C. for 4 hrs. and cooling 18 hrs.	..	"	"	Dwf: 70	..	"

N = sound ; S = slight ; D = destroyed ; F = fungus ; W = termites.

TABLE No. 2

Results of treatment of *Bambusa polymorpha* and *nutans* with 16·3 and 7·5 per cent of zinc chloride to which 2 per cent sodium dichromate† was added in each case. The bamboos were approximately 20 feet long and chemical analysis of treated bamboos were made on specimens taken at 2 feet from each end on inner and outer walls.

Serial No.	Percentage concentration of zinc chloride used for treatment	Absorption of zinc chloride in lb./cu. ft.				Duration of treatment in hours	Species of bamboo used
		Entering end		Dripping end			
		Inner	Outer	Inner	Outer		
1	16·3	1·34	1·23	0·92	0·78	3·0	<i>Bambusa polymorpha</i>
2	„	0·92	0·47	0·62	0·60	2·0	„
3	„	0·60	0·75	0·32	0·29	0·5	„
4	„	0·25	0·24	0·15	0·18	0·25	„
5	7·5	0·72	0·61	0·89	0·59	6·0	<i>Bambusa nutans</i>
6	„	0·97	0·70	0·89	0·40	5·0	„
7	„	0·62	0·55	0·62	0·85	4·0	„
8	„	0·28	0·42	0·44	0·39	3·0	„
9	„	0·49	0·31	0·18	0·17	2·0	„
10	„	0·28	0·38	0·22	0·30	1·0	„
11	„	0·55	0·65	0·46	0·57	6·0	„
12	„	0·74	0·60	0·35	0·46	5·0	„
13	„	0·66	0·42	0·41	0·39	4·0	„
14	„	0·38	0·57	0·38	0·38	3·0	„
15*	„	0·45	0·68	0·40	0·37	2·0	„
16	„	0·41	0·35	0·24	0·30	0·5	„

\* Absorption of zinc chloride in the septa is 0·59 lb./cu. ft.

† This small quantity of sodium dichromate is added to protect the apparatus from corrosion due to zinc chloride.

TABLE No. 3.—Results of treatment of *Bambusa polymorpha*, *Dendrocalamus strictus* and Zinc chloride to which 2% of Sodium dichromate was added

Serial No.	Species of bamboos treated	Approximate age of bamboo in months	Preservative used and its % conc. in water		Pneumatic pressure applied on the preservative solution in lb. and period of treatment in hours		Dripping of sap and preservative at butt end in minutes after start		Volume of sap and preservative flowed out in c.c.	
			Preservative	Conc.	Pressure	Period	Sap	Preservative	Sap	Preservative
1	2	3	4	5	6	7	8	9	10	11
1	BP	Not known	a	4	20	2.5	1	35	30.0	575.0
2	BP	"	a	4	20	3.0	1	12	285.0	910.0
3	BP	"	a	4	20	3.0	1	24	185.0	660.0
4	BP	"	a	4	20	3.0	2	15	215.0	4000.0
5	BP	"	a	4	20	3.0	5	10	5.0	770.0
6	BP	"	a	4	20	3.0	10	35	225.0	25.0
7	BP	"	a	4	20	3.0	20	25	25.0	105.0
8	BP	"	a	4	20	3.0	5	6	40.0	..
9	BP	"	b	10	20	3.0	1	11	140.0	3160.0
10	BP	"	b	10	20	3.0	5	50	60.0	150.0
11	DS	"	b	10	20	2.0	..	10	Nil	130.0
12	DS	"	b	10	20	7.0	7	20	85.0	85.0
13	DS	"	b	10	20	4.0	12	122	140.0	100.0
14	BP	40	b	10	20	3.0	2	22	45.0	625.0
15	BP	40	b	10	20	3.0	1	31	100.0	385.0
16	BP	28	b	10	20	3.0	3	20	125.0	925.0
17	BP	28	b	10	20	3.0	3	18	70.0	1135.0
18	BP	16	b	10	20	3.0	3	18	165.0	1600.0
19	BP	16	b	10	20	3.0	1	12	125.0	1140.0
20	DS	54	b	10	30	4.5	7	15	100.0	15.0
21	DS	54	b	10	30	7.5	1	167	35.0	15.0
22	DS	54	b	10	20	3.0	2	19	55.0	190.0
23	DS	42	b	10	30	6.0	2	49	130.0	240.0
24	DS	42	b	10	20	3.0	2	12	25.0	170.0
25	DS	30	b	10	30	6.9	25	205	160.0	40.0
26	DS	30	b	10	20	3.0	5	43	55.0	200.0
27	DS	18	b	10	30	6.0	1	172	150.0	50.0
28	DS	18	b	10	20	3.0	3	33	65.0	150.0

*Bambusa nutans* with Boliden salts ( *a* ); ASCU ( *b* ); Copper-chrome-boric composition ( *c* ); ( *d* ); and fire-proofing-cum-antiseptic composition ( *e* )

Size of bamboos				Volume of preservative absorbed by bamboo in c.c.	Absorption of preservative ( dry ) in lb.		Absorption of ZnCl <sub>2</sub> in lb. ( dry ) per cu. ft. ( by chemical analysis ) at 12° from the dripping end
Length in feet	Diameter at thin end and butt end in inches	Variation of wall thickness at thin end and butt end in inches	Approximate volume in cu. ft.		Per bamboo	Per cu. ft.	
12	13	14	15	16	17	18	19
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
20	1.05 to 2.25	0.20 to 0.45	0.106	745.0	0.164	1.547	..
25	1.1 to 1.9	0.25 to 0.50	0.134	1595.0	0.346	2.560	..
30	1.0 to 2.2	0.20 to 2.00	0.380	550.0	0.120	0.315	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
21	..	..	..	..	..	..	..
27	1.0 to 2.0	0.30 to 1.10	0.237	585.0	0.129	0.544	..
30	1.0 to 1.9	0.40 to 0.60	0.196	490.0	0.108	0.551	..
18	1.0 to 1.6	0.20 to 1.60	0.103	225.0	0.050	0.485	..
26	1.0 to 1.9	0.30 to 1.60	0.284	415.0	0.910	3.204	..
16	1.0 to 1.6	0.40 to 1.60	0.116	230.0	0.051	0.440	..
31	1.1 to 2.1	1.10 to 1.70	0.406	880.0	0.710	1.749	..
20	1.1 to 1.9	0.40 to 1.90	0.192	210.0	0.046	0.242	..
29	1.0 to 2.0	0.40 to 1.50	0.315	950.0	0.210	0.666	..
21	1.0 to 1.55	0.30 to 1.55	0.171	310.0	0.068	0.400	..

( contd. )

TABLE No. 3.—Results of treatment of *Bambusa polymorpha*, *Dendrocalamus strictus* and Zinc chloride to which 2% of Sodium dichromate was added

Serial No.	Species of bamboos treated	Approximate age of bamboo in months	Preservative used and its % conc. in water		Pneumatic pressure applied on the preservative solution in lbs. and period of treatment in hours		Dripping of sap and preservative at butt end in minutes after start		Volume of sap and preservative flowed out in c.c.	
			Preservative	Conc.	Pressure	Period	Sap	Preservative	Sap	Preservative
1	2	3	4	5	6	7	8	9	10	11
29	BP	53	c	10	20	3.40	1	23	120.0	1535.0
30	BP	53	c	10	20	3.50	1	15	110.0	1115.0
31	BP	41	c	10	20	3.0	3	15	100.0	1325.0
32	BP	41	c	10	20	2.66	1	15	180.0	1930.0
33	BP	29	c	10	20	3.00	1	11	90.0	1540.0
34	BP	29	c	10	20	3.00	2	28	130.0	3065.0
35	BP	17	c	10	20	3.0	1	18	150.0	1250.0
36	BP	17	c	10	20	3.75	1	15	60.0	1175.0
37	BP	52	d	17	25	6.0	1	18	65.0	985.0
38	BP	52	d	17	20	4.0	10	23	55.0	1550.0
39	BP	40	d	17	20	2.0	1	24	115.0	800.0
40	BP	40	d	17	20	3.0	6	20	135.0	1350.0
41	BP	40	d	17	20	3.5	1	9	130.0	2130.0
42	BP	28	d	17	20	3.0	20	50	155.0	1325.0
43	BP	28	d	17	20	3.0	15	20	20.0	950.0
44	BP	16	d	17	20	3.0	1	19	115.0	1485.0
45	BP	16	d	17	20	3.0	21	38	80.0	1325.0
46	DS	54	d	17	30	3.0	11	80	105.0	250.0
47	DS	54	d	17	30	4.66	30	120	75.0	250.0
48	DS	42	d	17	30	5.0	75	160	20.0	425.0
49	DS	42	d	17	30	3.2	1	60	115.0	410.0
50	DS	30	d	17	30	3.75	1	15	60.0	1175.0
51	DS	30	d	17	30	5.5	10	80	100.0	195.0
52	DS	18	d	17	30	3.0	29	80	85.9	105.0
53	DS	18	d	17	30	3.50	10	55	60.0	400.0
54	BN	..	e	25	20	6.0	7	15	15.0	2125.0
55	BN	..	e	25	20	6.0	5	15	50.0	2085.0
56	BN	..	e	25	20	6.0	13	24	15.0	1755.0

*Bambusa nutans* with Boliden salts (a); ASCU (b); Copper-chrome-boric composition (c); (d); and fire-proofing-cum-antiseptic composition (e)—(concl'd.)

Length in feet	Size of bamboos			Volume of preservative absorbed by bamboo in c.c.	Absorption of preservative (dry) in lb.		Absorption of ZnCl <sub>2</sub> in lb. (dry) per cu. ft. (by chemical analysis) at 12" from the dripping end
	Diameter at thin end and butt end in inches	Variation of wall thickness at thin end and butt end in inches	Approximate volume in cu. ft.		Per bamboo	Per cu. ft.	
12	13	14	15	16	17	18	19
21	2.2 to 3.2	0.40 to 1.30	0.417	675.0	0.253	0.607	..
21	2.3 to 3.4	0.30 to 0.50	0.243	340.0	0.075	0.308	..
21	2.3 to 4.6	0.30 to 1.60	0.648	675.0	0.253	0.390	..
21	2.3 to 3.5	0.20 to 0.60	0.248	360.0	0.079	0.319	..
21	2.3 to 2.8	0.15 to 0.80	0.254	310.0	0.068	0.268	..
21	2.4 to 3.1	0.30 to 0.70	0.143	850.0	0.187	1.307	..
21	2.4 to 3.3	0.20 to 0.80	0.356	335.0	0.074	2.073	..
21	2.3 to 2.4	0.20 to 0.40	0.151	775.0	0.177	1.172	..
21	2.4 to 3.0	0.40 to 1.20	0.422	815.0	0.351	0.832	0.46
21	2.3 to 3.0	0.20 to 1.20	0.186	1550.0	0.584	3.140	0.255
21	2.3 to 2.8	0.30 to 1.00	0.331	..	..	..	0.455
20	2.4 to 3.0	0.30 to 0.80	0.288	1225.0	0.495	1.700	0.475
21	2.2 to 3.4	0.20 to 0.30	0.153	75.0	0.637	4.163	0.37
21	2.3 to 3.4	0.40 to 2.80	0.752	675.0	0.223	0.283	0.63
21	2.2 to 3.0	0.20 to 0.20	0.116	435.0	0.163	1.542	..
21	2.3 to 2.7	0.25 to 1.60	0.475	815.0	0.306	0.640	0.435
21	2.4 to 3.2	0.50 to 1.00	0.413	175.0	0.068	0.165	0.46
27	1.0 to 2.1	0.30 to 1.10	0.248	445.0	0.167	0.673	0.37
26	1.0 to 1.8	0.40 to 1.00	0.208	410.0	0.154	0.740	..
26	1.0 to 2.0	0.30 to 0.20	0.940	405.0	0.151	0.160	0.56
26	1.0 to 1.7	0.30 to 1.30	0.216	210.0	0.079	0.364	0.58
28	1.0 to 2.1	0.40 to 1.10	0.270	775.0	0.177	1.118	0.45
25	1.0 to 2.0	0.20 to 1.80	0.273	475.0	0.178	0.652	0.40
26	1.2 to 2.0	0.60 to 1.00	0.272	385.0	0.144	0.526	..
25	1.0 to 1.7	0.30 to 0.90	0.172	540.0	0.202	1.465	0.66
23	2.3 to 3.0	0.5 to 1.5	0.53	2075.0	1.14	2.15	..
25	2.3 to 2.6	0.30 to 1.30	0.45	1615.0	0.88	1.9	..
27	1.7 to 2.6	0.70 to 1.5	0.45	2185.0	1.2	2.6	..

TABLE NO. 4

Table showing recommended preservatives, their concentration, absorption in bamboos and expected service life, for the treatment of green bamboos for diverse purposes.

Serial No.	Diverse uses of treated bamboos	Recommended				Expected service life in years
		Preservative	Concentration %	Absorption lb./cu. ft. dry salt	Duration of treatment in hrs.	
1	2	3	4	5	6	7
1	Use in the open and in contact with the ground : Fence posts, pale fencing, flag staff, scaffolding .. .. Supports to cane and betel plant ..	A to C E	A to C, 8, B-4 E-10	A, B, C 0.3 to 0.4 0.3	3-4 2	10-15 8-10
2	House building - rafters, purlins, trusses, tent posts, etc. .. ..	A to E	A & C-6; B-3; D-8; E-10	A to D-0; 0.2 to 0.3; E 0.5	2-3	15-20
3	Reinforcing concrete walls .. .. Chicks, ceiling and door panels .. .. Reinforcing mud walls .. ..	E & F F, G, H, I D & E	6 F, G, H-6; I-2 D-6; E-8	0.2 0.1-0.2 0.2 to 0.3	1-2 1 2	25-30 10 10-15
4	All utility articles like baskets, winnows, sieves, etc. .. ..	G & H	5	0.1	0.5	5-8
5	Prophylactic purposes .. ..	A to I depending on end use of bamboo	6-8	0.05	0.5	5
6	Fire protection { inside house .. .. open .. ..	J .. ..	25 .. ..	2 to 3 .. ..	6 to 8 .. ..	15-20 10-15

A Ascu : composition .. ..  $\text{As}_2\text{O}_5 : \text{CuSO}_4, 5\text{H}_2\text{O} : \text{Na}_2\text{Cr}_2\text{O}_7 :: 1 : 3 : 4$ .

B Boliden salts S25

C Celcure : composition .. ..  $\text{CuSO}_4 : \text{Na}_2\text{Cr}_2\text{O}_7 : \text{Acetic acid} :: 5.6 : 5.6 : 0.25$ .

D Copper-chrome-boric composition .. .. Boric acid :  $\text{CuSO}_4, 5\text{H}_2\text{O} : \text{Na}_2\text{Cr}_2\text{O}_7 :: 1.5 : 3 : 4$ .

E Chromated zinc chloride .. .. Zinc chloride :  $\text{Na}_2\text{Cr}_2\text{O}_7 :: 1 : 1$ .

F Zinc chloride plus Sodium dichromate ..  $\text{ZnCl}_2 : \text{Na}_2\text{Cr}_2\text{O}_7 :: 5 : 1.5$ .

G Boric acid + Borax + Sodium dichromate Boric acid : Borax :  $\text{Na}_2\text{Cr}_2\text{O}_7 :: 2 : 2 : 0.5$ .

H Boric acid + Borax .. .. Boric acid : Borax :: 1 : 1.

I Sodium pentachlorophenate

J Fire-proof-cum-antiseptic composition .. Boric acid :  $\text{CuSO}_4, 5\text{H}_2\text{O} : \text{ZnCl}_2 : \text{Na}_2\text{Cr}_2\text{O}_7 :: 3 : 1 : 5 : 6$ .

TABLE NO. 5

*Table giving addresses of firms dealing with preservative chemicals and approximate cost per cwt.*

Serial No.	Preservative	Address of firms	Cost per cwt.
			Rs.
1	*Ascu <sup>1</sup> and *Copper-chrome-boric-composition <sup>2</sup> ..	A	84 <sup>1</sup> ; 83 <sup>2</sup>
2	*Boliden salts ( S-25 ) .. ..	B	158
3	Copper sulphate .. ..	C & D	88
4	Arsenic pentoxide .. ..	G	65
5	Zinc chloride .. ..	C & G	62
6	Sodium dichromate.. ..	H	85
7	Boric acid and Borax .. ..	G	37
8	Sodium pentachlorophenate .. ..	E & F	242

\* Patented compositions.

( 1 ) For Govt. use only.

( 2 ) Without royalty.

A M/s. Ascu Wood Products Ltd., 6, Mangoe Lane, Calcutta.

B M/s. Larsen & Toubro Ltd., Engineers, P.O. Box No. 98, Bangalore—1.

C M/s. Bengal Chemical & Pharmaceutical Works Ltd., Calcutta.

D M/s. Imperial Chemical Industries ( India ) Ltd., Kanpur.

E M/s. Shalimar Tar Products ( 1935 ) Ltd., 6, Lyons Range, Calcutta.

F M/s. Monsanto Chemicals of India Ltd., P.O. Box No. 344 A, Bombay—1.

G M/s. Suresh & Co. Ltd., 57, Lohar Streat, Bombay—2.

H M/s. The Pioneer Chromate Works Ltd., P.O. Box No. 1084, Bombay—1.

TABLE No. 6

*Statement showing annual yield of bamboos in the various States of India*

Serial No.	State	Total land area (sq. miles)	Population according to 1951 census (in thousands)	Total forest area (sq. miles)	Annual yield of bamboos in thousand tons
1	2	3	4	5	6
1	Assam ..	85,007	9,690	21,923	251
2	Bihar ..	70,330	40,219	13,900	..
3	Bombay ..	1,11,434	35,944	17,504	293
4	Madhya Pradesh ..	1,30,272	21,328	40,907	..
5	Madras ..	1,27,790	56,952	33,696	..
6	Orissa ..	60,136	14,644	4,552	..
7	Punjab ..	37,378	12,639	4,873	..
8	Uttar Pradesh ..	1,13,409	63,254	21,874	48
9	West Bengal ..	30,775	24,787	3,831	13
10	Hyderabad ..	82,168	18,653	9,455	..
11	Jammu & Kashmir ..	92,780	4,370	11,058	..
12	Madhya Bharat ..	46,488	7,942	14,153	57
13	Mysore ..	29,489	9,072	4,561	95
14	P.E.P.S.U. ..	10,078	3,469	331	..
15	Rajasthan ..	1,30,207	16,298	12,782	..
16	Saurashtra ..	21,451	4,136	631	2
17	Travancore-Cochin ..	9,144	9,265	3,056	..
18	Ajmer ..	2,417	593	593	..
19	Bhopal ..	6,879	838	1,550	..
20	Bilaspur ..	453	128	200	..
21	Coorg ..	1,586	229	1,156	55
22	Delhi ..	578	1,744	..	..
23	Himachal Pradesh ..	10,451	989	3,012	7
24	Kutch ..	16,724	568	169	..
25	Manipur ..	8,628	579	2,250	..
26	Tripura ..	4,032	650	3,610	..
27	Vindhya Pradesh ..	23,603	3,577	7,968	67
28	The Andamans and the Nicobar Islands ..	3,125	31	2,500	..
	TOTAL ..	1,266,892	3,61,688	2,42,104	888

TABLE No. 7

Statement showing quantities and cost of timber, bamboos and grasses including preservative treatment required for building houses shown in Fig. 1. ( Cost of labour is not included )

Type of house	Requirements of timber in c. ft.		Requirements of bamboos Nos.		Requirements of thatch grass	Total requirements			Requirements of preservative ( Ascu ) for the treatment of			
	Walls	Trusses	Walls	Roof	lb.	Timber c. ft.	Bamboo c. ft.	Thatch grass lb.	Timber	Bamboo	Grasses	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
A	70	90	200	100	10,000	160 Rs. 640	300 Rs. 90	10,000 Rs. 315	48 Rs. 48	90 Rs. 90	334 Rs. 334	.. Rs. 1517
B	30	45	100	50	4,000	75 Rs. 300	150 Rs. 45	4,000 Rs. 126	22.5 Rs. 22.5	45 Rs. 45	134 Rs. 134	.. Rs. 672
C	45	45	100	50	4,000	90 Rs. 360	150 Rs. 45	4,000 Rs. 126	27 Rs. 27	45 Rs. 45	134 Rs. 134	.. Rs. 737
D	35	45	100	50	3,000	80 Rs. 320	150 Rs. 45	3,000 Rs. 95	24 Rs. 24	45 Rs. 45	100 Rs. 100	.. Rs. 629

The following rates were taken into consideration in the above calculations :—

- ( 1 ) Timber—*chir* @ Rs. 4/- per c. ft.
- ( 2 ) Bamboos— @ Rs. 6/- per 20 ( each bamboo is equal to 1 c. ft. ).
- ( 3 ) Thatch grass— @ Rs. 50/- per 1,000 pulas or 1,600 lb.
- ( 4 ) Ascu— @ Re. 1/- per lb. including transport and cost of treatment for Govt. use.
- ( 5 ) Absorption of preservative per c. ft. - 0.3 lb. for bamboos and timber ; and 0.3 lb. per 10 lb. of grass.
- ( 6 ) Anticipated life 15 to 20 years.

TABLE No. 8

*Annual charges<sup>(1)</sup> for treated and untreated timber, bamboos and thatch grass for house building purposes*

Materials used	Service life in years		Initial cost	Cost of (2) treatment	Total cost of treated material	Annual charges	
	Untreated	Treated				Untreated	Treated
1	2	3	4	5	6	7	8
Timber <i>Chir</i> ( <i>Pinus longi- folia</i> ).	2	15 to 20	Rs. 4 per c. ft.	Rs. 1/3	4½	Rs. 2·16	Rs. 0·433 to 0·350
Bamboos .. ..	2	15 to 20	Rs. 6 for 20 ( 1 c. ft. each )	6	12	3·44	1·20 to 0·96
Thatch grass ( local, Dehra Dun ).	2	15 to 20	Rs. 50 for 1000 pulas or 1600 lb.	48	98	27·00	9·80 to 7·84

( 1 ) Annual charges or the cost per year required to extinguish an interest bearing debt during a period of years corresponding to the life of the material in service. The interest is taken at 5 per cent which includes interest at 3 per cent and expenses for annual maintenance at 2 per cent on capital. The formula used for this calculation is  $A = P \left( r + \frac{r}{(1+r)^n - 1} \right)$  where A is the annual charge or cost per year ; P is the first cost of the material ; r is the rate of interest ( expressed in decimal ) and n is the estimated number of years of service.

( 2 ) The cost of treatment is calculated at 0·3 lb. absorption of the preservative Ascu for 1 c. ft. of timber or bamboos and 0·3 lb. for 10 lb. of thatch grass. The cost of the preservative including transport charges and treatment costs is taken at Re. 1/- per lb. for Government use.

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The first part of the paper discusses the importance of the study of the history of the United States. It is pointed out that the study of history is not only a means of understanding the past, but also a means of understanding the present and the future. The author argues that the study of history is essential for the development of a nation and for the well-being of its people. He also discusses the role of the historian in society and the importance of the historical method. The second part of the paper is a critical analysis of the work of the American historians of the late nineteenth century. The author discusses the work of such historians as F. J. Turner, W. D. Howells, and J. W. Aldrich. He points out that these historians were concerned with the study of the American West and the American frontier. He also discusses the work of the European historians of the same period, such as H. P. Morgan and J. H. Morgan. The author argues that the American historians of the late nineteenth century were concerned with the study of the American West and the American frontier, while the European historians were concerned with the study of the American Revolution and the American Civil War. The third part of the paper is a critical analysis of the work of the American historians of the early twentieth century. The author discusses the work of such historians as W. D. Howells, J. W. Aldrich, and F. J. Turner. He points out that these historians were concerned with the study of the American West and the American frontier. He also discusses the work of the European historians of the same period, such as H. P. Morgan and J. H. Morgan. The author argues that the American historians of the early twentieth century were concerned with the study of the American West and the American frontier, while the European historians were concerned with the study of the American Revolution and the American Civil War. The fourth part of the paper is a critical analysis of the work of the American historians of the late twentieth century. The author discusses the work of such historians as W. D. Howells, J. W. Aldrich, and F. J. Turner. He points out that these historians were concerned with the study of the American West and the American frontier. He also discusses the work of the European historians of the same period, such as H. P. Morgan and J. H. Morgan. The author argues that the American historians of the late twentieth century were concerned with the study of the American West and the American frontier, while the European historians were concerned with the study of the American Revolution and the American Civil War.



